Evaluation

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DOUGIAS-FIR TUSSOCK MOTH INFESTATIONS IN NORTHERN CALIFORNIA - 1964

By

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INTRODUCTION

The Douglas-fir tussock moth is an insect native to California and much of the Douglas-fir and true fir forests of western North America. In California it is a major defoliator of white fir. Although epidemics of this moth have occurred at infrequent intervals in California, when outbreaks do arise the moth is capable of causing severe and extensive damage in a comparatively short time.

Studies have been made of two previous outbreaks in California; one near Mammoth Lakes, which lasted from 1934 to 1938, and the other on the Stanislaus National Forest which was discovered in 1954 and was controlled by aerial spraying in 1956.(1) These studies indicated that serious damage occurred during and following the epidemics. Losses were caused by tree killing, top killing, and growth loss from defoliation, and tree killing by other insects, such as bark beetles, which attacked the weakened trees. Losses as great as 20 to 29 percent of the original stand volume were measured in the studies.

The current Douglas-fir tussock moth problem was first reported in 1962 when light feeding damage was noticed in Modoc and El Dorado Counties.(2) These infestations were kept under surveillance during 1963. A ground reconnaissance of the Iron Mountain (El Dorado County) infestation was made in November 1963. It was observed that although there was an abundance of cocoons in the area, very few of the cocoons bore egg masses. Egg masses were collected and later parasites emerged from them. From this information it was suspected that the outbreak was declining.(3) In June of 1964, cocoon counts at Iron Mountain were also made as a follow up to the November inspection. Sixty-three trees were sampled in various portions of the area and 2,306 cocoons were examined. Among the 2,306 cocoons, 81 new egg masses and 68 old egg masses were recorded. Again the relative scarcity of egg mass in relation to total cocoons and the nearly equal ratio between new and old egg masses indicated a declining population, particularly when rearings showed substantial egg parasitism.(4) However, damage continued in the surveyed area and a new outbreak center of equal size developed on a neighboring ridge. In this instance, an egg population of 1.3 new masses per sample tree* was sufficient to maintain a damaging infestation.

At Knox Mountain (Modoc County), some tussock moth sampling experience was also accumulated during the summer of 1964. This work resulted from a need to evaluate the effect of an aerial spray job applied for white-fir sawfly control. Neodiprion abietis complex (Harris) was present on 2,800 acres

*The sampling unit was the lower six feet of the crown.

sprayed with DDT and 320 acres sprayed with malathion in late June 1964 to control the sawfly.(5) The spray was applied at the time the tussock moth eggs were also hatching and it was felt that control of both insects might be obtained within the sprayed areas.

During July and August 1964, 39 sample plots were taken; 14 plots within the DDT treated area, 7 plots in the malathion treated area and 18 plots outside the treated areas. In the sprayed areas, the plot locations were the same as the plots used to evaluate the sawfly control and outside of the sprayed areas the plot locations were randomly selected in an area not contaminated by the spray. Each plot consisted of 10 trees; for each tree the cocoons and egg masses on the bottom six feet of the crown and larval samples from twigs were recorded. The larval samples proved to be ineffective in measuring the population because the larvae frequently drop when disturbed and they congregate in different portions of the crown depending upon the amount of defoliation which has occurred. Comparable standard samples are therefore difficult or impossible to obtain. Beating branches and collecting from drop cloths also would give questionable results since the larvae are concentrated in different parts of the crowns at various times.

The July and August survey recorded the egg masses which hatched in 1963 or before (old masses) and those which had just hatched (new masses). The areas were again resampled in October and egg masses which hatched in 1964 and those which will hatch in 1965 were recorded. On the basis of a large sample in the unsprayed areas, the general infestation is seen to be rising sharply; this up trend is also evident in the malathion treated area, but in the DDT treated area, no new 1965 egg masses were found:

AVERAGE EGG MASSES PER SAMPLE TREE*

DDT Treated Area			Malathion Treated Area			Unsprayed Area		
Hatch 1963	Hatch 1964	Hatch 1965	Hatch 1963	Hatch 1964	Hatch 1965	Hatch 1963	Hatch 1964	Hatch 1965
0.06	0.69	0.0	0.0	0.44	2.9	0.006	0.27	7.19

*Table based on the following data:

DDT Treated Area
- 1963 hatch - 9 egg masses found on 140 sample trees.
- 1964 hatch - 97 egg masses found on 140 sample trees.
- 1965 hatch - 0 egg masses found on 140 sample trees.

Malathion Treated Area
- 1963 hatch - 0 egg masses found on 70 sample trees.
- 1964 hatch - 31 egg masses found on 70 sample trees.
- 1965 hatch - 43 egg masses found on 15 sample trees.

Unsprayed Area
- 1963 hatch - 1 egg mass found on 180 sample trees.
- 1964 hatch - 269 egg masses found on 990 sample trees.
- 1965 hatch - 7119 egg masses found on 990 sample trees.

Our evaluation of the effect on the tussock moth of spray application at Knox Mountain is that DDT was effective and malathion was not effective as applied in late June 1964.

In August 1964, aerial and ground detection reports showed that additional infestation centers were developing in several new locations in northern California. The following portion of the report records the procedure and results of an extensive appraisal survey of infested areas made in the fall of 1964. The survey was patterned after similar work done in Idaho and Montana by Region 1 of the U. S. Forest Service.(6)

TECHNICAL INFORMATION AND DESCRIPTION OF THE CURRENT EPIDEMIC

Causal Agent. The Douglas-fir tussock moth (Hemerocampa pseudotsugata - McDunnough) is the insect primarily responsible for the widespread defoliation of white fir in California in 1964. Damage to the host tree results from the feeding of the caterpillar stage of the moth. The life cycle and habits of the insect are well covered in the literature; particularly in the Forest Pest Leaflet #86 which reports the important facts known about the Douglas-fir tussock moth throughout its range.(7) The most important discrepancy between the behavior of the current California epidemic and the general information presented in the literature was: in the summer of 1964, the tussock moth eggs hatched in early July and the stages of the life cycle occurred about a month later than the latest periods reported from previous observations. For example, the leaflet indicates that the eggs hatch in late May and the moth development is completed by late July to early September when the adults appear, depending on season and location. However, this year in California, egg hatch occurred in early July and adult emergence took place mostly during the month of October. This delay in moth development was probably due to the late season experienced this year.

Host Tree Attacked. Damage by the Douglas-fir tussock moth in this and past outbreaks in California has been primarily limited to white fir (Abies concolor). In locations of moderate to heavy defoliation, ponderosa pine trees in the smaller size classes were also frequently attacked. Although red fir is reported as a nonhost, experienced foresters reported the defoliation of red fir in predominately white fir stands where feeding was heavy. Douglas-fir has not been present in any of the infected areas in the current outbreak.

Type of Damage. The caterpillars of the Douglas-fir tussock moth defoliate trees by girdling the needles rather than consuming the entire needle. The damaged needles turn brown, die and eventually drop from the twig. Feeding is at first confined to new foliage. If the supply of new needles is used up, the older needles are attacked. In the current epidemics, all levels of damage from very slight loss of new needles to 100 percent defoliation are common. Needle killing progresses from the top of the crown downward and from the branch tips into the interior of the crown. Where partial defoliation is present, the damage is most severe in the tops of the trees.

Location and Extent of the Outbreaks. The known outbreaks of the tussock moth have been mapped as follows:

Location			Extent
Modoc County	-	Knox Mountain	59,730 Acres
" "	-	Stowe Reservoir	470 "
" "	-	Roney Flats	2,280 "
Lassen County	-	Fredonyer Peak	1,600 "
Plumas County	-	Diamond Mountain	12,300 "
El Dorado County	-	Iron Mountain	1,830 "
		Total - - - -	78,210 Acres

In addition, incipient outbreaks have been detected at Fredonyer Pass, Lassen County; Pinecrest, Tuolumne County, and Ross Creek, Modoc County.

Appraisal Survey of Infested Areas. The appraisal job for the current Douglas-fir tussock moth outbreaks was conducted as a cooperative effort. In all stages of the work, the talent and manpower of private concerns, the University of California, the California Division of Forestry, and the Bureau of Land Management assisted the Forest Service in gathering the facts concerning this problem.

Shortly after defoliation became visible in mid-July, cooperative detection reports began arriving at the Forest Service Regional Office in San Francisco. Some outbreaks were reported two or three times by different observers. The Statewide Detection System, established several years ago by the California Pest Control Action Council, functioned very effectively in this instance.

In mid-August, fix-wing aerial flights of the outbreaks were conducted to roughly map the defoliated areas and to scout for additional infestations. Only one additional outbreak was found. Regional Office, National Forest, Experiment Station, and California Division of Forestry observers participated in this operation.

Following the reconnaissance flights, more detailed mapping of the outbreaks was accomplished by aerial and ground inspection. This operation was designed to delineate a fairly accurate boundary for the infestations and to sub-divide the areas into light, medium and heavy defoliation classes. The larger outbreaks, at Knox Mountain and Diamond Mountain, were mapped by helicopter. Verne Osburn, (California Division of Forestry) was chief observer on both areas, assisted by Tom Glunt (Shasta Forests Company) at Diamond Mountain.

The University of California has been conducting aerial photograph studies of insect activity on Blodgett Forest near the Iron Mountain outbreak. This provided an opportunity to use aerial photographs in mapping the Iron Mountain infestation. Gene Thorley, of the University of California, obtained camouflage detection film coverage of the entire area and interpreted the picture.

The other smaller infestations of the tussock moth at Stowe Reservoir, Roney Flats and Fredonyer Peak were mapped from the ground.

FALL EVALUATION SURVEY OF ALL INFESTED AREAS

A. Survey Plan

The larger outbreaks were mapped according to degree of damage by helicopter. The Iron Mountain infestation was mapped by aerial camouflage detection pictures. To obtain good coverage of all degrees of damage within the infestations with economy of field work, the mapping was used as a basis for stratifying the sample. One plot was taken for roughly 150-200 acres of each defoliation level in the heavy, medium and light classifications delineated. A fourth classification was called "zero to light." This class represented the areas between the other delineated classes and the areas on the fringe of the outbreaks. The "zero to light" class represented the largest acreage and was sampled at one half the intensity of the other classes.

In the smaller outbreaks, mapping and the recording of plot data was done at the same time.

In the large infestations at Knox Mountain and Diamond Mountain, sample plot locations were chosen on a random basis within the damage level classifications. This was done by super-imposing a grid over the infestation map. The grid was composed of four vertical and four horizontal lines per section. Grid intersections were designated as possible plot locations; thus there were 16 possible plot locations per section on the average.*

A list was then compiled of all the grid intersections falling within each damage class; however, obviously inaccessible locations were not recorded. These lists were arranged in several columns of 23 lines each. Plot locations were then randomly selected by drawing two numbers: the first number to designate the column and the second number to choose the line within the column for each plot.

B. Plot Design

Biological information concerning the outbreak was recorded from five fir trees at each plot location.** The lower six feet of the tree was the sampling unit. Cocoon and egg mass counts from the bole, branches and foliage were recorded in the data. The survey was limited primarily to saplings and small poles since the larger size classes often have no live crown within six feet of the ground. Each sample attempted to include a portion of the live crown since there is evidence that female larvae prefer live foliate for a pupation site.(8)

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*The grid pattern did not parallel the section lines exactly, due to irregular sized sections.

**On a few plots where cocoons or egg masses were very numerous, a smaller number of trees were sampled.

At each sample tree, the information recorded consisted of cocoon and egg mass counts, segregated as follows: new egg masses; old egg masses (i.e., hatch 1964 or before); unemerged cocoons without egg masses; emerged cocoons without egg masses. At Diamond Mountain, a complete count of these four categories was recorded for each sample tree. On the rest of the areas, a complete count of new and old egg masses was taken for each sample tree but the tally of unemerged and emerged cocoons without egg masses was kept for each tenth tree.

The information to be derived from these samples is as follows:

1. The ratio between old and new egg masses was used as an index of population trend of the tussock moth. It cannot be considered a definite measurement of the trend since the old mass counts could include masses of more than one generation. Also, tussock moth mortality and egg mass distribution within the tree crowns might not be the same for each generation. However, the comparison between new and old egg masses was the best indicator available for judging the probable trend.

2. The number of old egg masses per sample was associated with the degree of defoliation observed in the vicinity of the sample, assuming that nearly all the "old masses" were only one year old. Comparing the number of new egg masses per sample with the old, gives some idea of the damage level to be expected in 1965. Again, this is only a rough approximation because the portion of female moths that oviposited in the sampling unit may have changed and tussock moth survival next generation may be different.

3. Recording emerged and unemerged cocoons which did not bear egg masses indicated primarily whether or not the survey was being conducted too early. Since the number of unemerged cocoons was quite high, a sample of these were dissected in the early part of the survey. Dissection showed that by the second week of October, nearly 100 percent of the unemerged pupae were dead or parasitised, although emerging adults could still be found in the field. Another interesting observation is that in some areas, cocoons without egg masses far outnumber cocoons with egg masses. The cause of this is not apparent but it could indicate some imbalance in sex ratio, lack of success of many females in depositing eggs or some difference in survival of male and female pupae. Condrashoff and Grant report higher mortality of female pupae than males in Canada.(9)

In addition to cocoon and egg mass data, the observed defoliation at each plot was recorded along with the aspect and topograph of the plot. During the ground survey the damage class, "zero to light," was converted to the "very light class" by deleting nontype or noninfested areas from the survey. The following guidelines for judging defoliation damage was provided to promote a uniform reporting of the degree of defoliation during the survey.

> O-L = none to slight browning of <u>new</u> foliage on any of the trees. In these areas also search for cocoons and write "Present" or "Absent" to indicate if the tussock moth can be found by a reasonable search of the vicinity.

L = browning of new needles only, up to killing of both new and old foliage in the upper one-third of the crown of 30 percent of the trees or less. None of the trees over one-third defoliated.

M = new foliage killed and both new and old foliage killed in the upper one-third to two-thirds of the crown of 30 percent of the trees or less. None of the trees completely defoliated.

H = complete kill of foliage in the upper one-third to two-thirds of the crown of more than 30 percent of the trees and/or complete defoliation of some of the trees.

Loss of 75 to 100 percent of the needle complement will be considered complete defoliation. Plot vicinity means within a couple of chains of the sample trees.

C. Field Work

Sampling the infestations began with Diamond Mountain on October 5 and continued, intermittently, through the first week of November. In all, 44 men from Federal, State, and private organizations participated in the survey.

In general the field work progressed quite rapidly and smoothly since the men engaged in it were experienced Foresters. In collecting plot data numerous notations were made which were used to correct the map derived from the helicopter survey. The helicopter mapping served very well as a basis for distributing plots among the various damage classes but corrections were needed to provide the final map of the surveyed areas. The biological data collected and the discussion for each infested area are considered separately in the following section. Maps of the infestations are included in the Appendix.

In addition to this study of the tussock moth epidemic, an independent investigation of the parasite complex is being conducted by Dr. Don Dahlsten of the University of California. The results of his work, when they become available, may modify some of the findings of this survey.

BIOLOGICAL DATA AND DISCUSSION

1. Knox Mountain

This is the largest and most destructive outbreak in the current epidemic. The aerial and ground survey indicates that the infestation covers some 59,730 acres at the present time. Heavy defoliation has occurred on about eight percent of the area, medium defoliation on 12 percent, light defoliation on 21 percent, and very light defoliation on about 59 percent.

SUMMARY OF EGG MASS DATA - KNOX MOUNTAIN

Defoliation Class	No. of Samples (Trees)	Number of Egg Masses Recorded		Number of Egg Masses Per Sample		Ratio of Old Masses Per New Masses
		New	Old	New	Old	
Heavy	85	4,434	161	52.2	1.9	1/27.5
Medium	120	2,014	58	16.8	0.5	1/34.7
Light	205	489	25	2.4	0.12	1/19.6
Very Light	580	241	21	0.42	0.04	1/11.5
TOTAL OR AVERAGE	990	7,178	265	7.25	0.27	1/27.1

Our interpretation of this information is that substantial tree mortality and top killing will result from this year's defoliation in the heavy areas and some mortality and top killing in the medium areas. The smaller size classes will suffer the greatest loss. In the light and very light areas, damage will largely be confined to growth loss. Regarding Christmas tree management areas, it appears that in the heavy and medium areas this product has been largely eliminated for many years.

A strong increase in the infestation is indicated for all areas. If nothing is done to halt the epidemic, damage can be expected to increase and spread next year. Heavy tree killing in all size classes will occur in areas classified as heavy and medium, and much of the area classified as light and very light will suffer severe damage. The outbreak will probably spread to include all of the fir type in the Knox Mountain area. On the other hand, the aerial application of DDT properly timed could be expected to reduce the tussock moth population to a low level and prevent further damage next year in the areas treated.

From an insect control standpoint alone, aerial spraying of all infested areas is indicated. The cost of spraying, in terms of cash and adverse side effects, must be weighed against the values at stake to determine the proper action to take.

2. Diamond Mountain

This is the second largest outbreak in the current epidemic. The aerial and ground survey indicates that the infestation covers some 12,300 acres at the present time. Of this, approximately two percent has suffered heavy defoliation, 11 percent medium defoliation, 29 percent light defoliation, and 58 percent very light defoliation.

The character of the outbreak and the probable population trend is indicated by the following summary

SUMMARY OF EGG MASS DATA - DIAMOND MOUNTAIN

Defoliation Class	No. of Samples (Trees)	Number of Egg Masses Recorded: New	Old	Number of Egg Masses Per Sample: New	Old	Ratio of Old Masses Per New Masses
Heavy	6	210	64	35.0	10.7	1/3.28
Medium	25	128	42	5.1	1.7	1/3.05
Light	65	132	44	2.0	0.7	1/3.00
Very Light	130	32	41	0.2	0.3	1/0.78
TOTAL OR AVERAGE	226	502	191	2.22	0.84	1/2.63

The above summary indicates that the Diamond Mountain outbreak does not threaten as great an increase next year as Knox Mountain. The ratio of old egg masses to new is considerably lower and it appears that a greater egg population is required to lead to the same level of damage. This suggests that natural enemies are holding down the Diamond Mountain outbreak more effectively. In the very light areas, the figures suggest that some decline in population is taking place. However, there is no indication of a collapse of the epidemic next year. Our interpretation of this data is that the Diamond Mountain infestation will remain stable or increase slightly in intensity and extent next year. A second defoliation of the trees in the heavy and medium areas will increase tree mortality and top killing considerably, however, and continued defoliation will have a serious impact on the smaller trees in the light areas as well. Christmas tree values will be damaged in all infested areas.

The control recommendations at Diamond Mountain are not as clearly indicated as that for Knox Mountain. The survey suggests that the heavy, medium and light areas should be sprayed if additional economic damage is to be avoided next year. However, there is some hazard of perpetuating the problem in allowing a large, very lightly infested area to go unsprayed on the fringe of the treated area. The configuration of the outbreak suggests another possible treatment plan: nearly all of the damaging infestation exists east of the narrow portion of the outbreak on Willard Creek. Treatment could be confined to the infested areas east of Willard Creek and Indicator Peak and a control decision postponed for one more year on the areas west of this line. However, due to the high value of the timber, the landowners do not wish to risk further damage or spread in the area. The private landowners through the Forest Pest Control Action Council recommended spraying of the entire infestation at their meeting of November 18, 1964.

3. Stowe Reservoir

Stowe Reservoir, although small in size, is the most intense outbreak in the current epidemic. Extremely heavy defoliation may result in group kills of trees in some spots from this year's feeding alone. An emergency aerial spray application of malathion on 200 acres in early August 1964 was not effective in curtailing the damage.

The following summary of egg mass data shows the startling increase in population which is now taking place:

SUMMARY OF EGG MASS - STOWE RESERVOIR

Defoliation Class	No. of Samples (Trees)	Number of Egg Masses Recorded: New	Old	Number of Egg Masses Per Sample: New	Old	Ratio of Old Masses Per New Masses
Heavy	2	1,904	15	952.0	7.5	1/126.9
Medium	5	168	20	33.6	4.0	1/8.4
Light	5	149	12	29.8	2.4	1/12.4
Very Light	-	-	-	-	-	-
TOTAL OR AVERAGE	12	2,221	47	185.1	3.9	1/47.3

In the absence of control, we would expect heavy tree mortality in all portions of this infested basin next year. It is also possible that a large spread of the infestation to stands adjacent to the basin will occur.

We recommend aerial spraying of all infested areas with DDT to control this intense outbreak.

4. Roney Flats

Limited sampling at Roney Flats indicates that this infestation is stable. Fairly heavy parasitism of the pupae stage has also been reported. This appraisal is based on inadequate samples and further study of the area is needed before action is taken. However, due to the very heavy defoliation that occurred in spots there this year, spraying of the area is recommended for 1965.

A summary of the egg mass data collected on the Roney Flats plots is as follows:

SUMMARY OF EGG MASS - RONEY FLATS

Defoliation Class	No. of Samples (Trees)	Number of Egg Masses Recorded: New	Old	Number of Egg Masses Per Sample: New	Old	Ratio of Old Masses Per New Masses
Heavy	5	41	18	8.2	3.6	1/2.3
Medium	10	54	21	5.4	2.1	1/2.6
Light	5	1	4	0.2	0.8	1/0.25
Very Light	-	-	-	-	-	-
TOTAL OR AVERAGE	20	96	43	4.8	2.2	1/2.2

5. Fredonyer Peak

The outbreak on the east side of Fredonyer Peak is unusual in that the heaviest defoliation is present at the lower elevations. In most tussock moth infestations the ridge tops are usually the most heavily damaged.

The survey in this area indicates that the infestation is increasing. The summary of the egg mass data collected in the Fredonyer Peak outbreak is as follows:

SUMMARY OF EGG MASS DATA - FREDONYER PEAK

Defoliation Class	No. of Samples (Trees)	Number of Egg Masses Recorded: New	Old	Number of Egg Masses Per Sample: New	Old	Ratio of Old Masses Per New Masses
Heavy	20	1,541	168	77.1	8.4	1/9.18
Medium	15	514	31	34.3	2.1	1/16.58
Light	15	484	12	32.3	0.8	1/40.33
TOTAL OR AVERAGE	50	2,539	211	50.8	4.2	1/12.0

Our appraisal of this outbreak is that aerial spraying would be required to avoid increased damage next year. Some tree mortality and top kill will probably result from this year's feeding. If the trees are again defoliated next year, as the survey indicates they will be, the number of trees top killed and completely killed can be expected to rise considerably.

An evaluation by the land managers of the increased threat in relation to the values threatened is needed to determine the proper action to take in this situation. Also, there is an infested area some three miles north of Fredonyer Peak, which was not included in this survey because of inclement weather. Investigation will be made to see what values are endangered in this area as well in 1965.

6. Iron Mountain

The Iron Mountain infestation is the third largest area involved in the current epidemic. This is the area where the first evaluation was made in June 1964. At that time a decline in the outbreak was expected. However, defoliation continued and a new outbreak developed on a nearby ridge (Baltic Ridge).

In November 1964, the area was again surveyed with both the new and old centers of infestation sampled. A summary of the egg mass data is as follows:

SUMMARY OF EGG MASS DATA - IRON MOUNTAIN-BALTIC RIDGE

Defoliation Class	No. of Samples (Trees)	Number of Egg Masses Recorded: New	Old	Number of Egg Masses Per Sample: New	Old	Ratio of Old Masses Per New Masses
Heavy	10	3	25	0.3	2.5	1/0.12
Medium	25	2	38	0.05	1.5	1/.05
Light	20	0	11	0	0.6	-
Very Light	25	0	8	0	0.3	-
TOTAL OR AVERAGE	80	5	82	0.06	1.02	1/.06

Again we are predicting that the tussock moth population in the Iron Mountain area is declining. Under these circumstances it appears that chemical control of this infestation is not needed at this time. The private landowner in the area is apprehensive, however, of further damage next year. One possible course of action would be to conduct a follow-up appraisal next summer, after most of the eggs had hatched, to see if appreciable damage to new foliage was taking place. The successful 1956 aerial spray project was conducted when the larvae were about three-fourths grown.(9) This shows that the tussock moth can be controlled with spraying late in larval development.

RECOMMENDATIONS

Land managers should seriously consider aerial spray control of the Douglas-fir tussock moth in areas where the survey indicates an increasing population or a population persisting at an economically damaging level. These areas are as follows:

Knox Mountain - approximately		59,730 Acres
Stowe Reservoir	- "	470 "
Fredonyer Peak	- "	1,600 "
Diamond Mountain	- "	12,300 "
Roney Flats	- "	2,280 "
Total - - - -		76,380 Acres

Spraying will probably not be needed next year at:

Iron Mountain - approximately 1,830 Acres

DDT is the only insecticide known to be effective against the Douglas-fir tussock moth. An aerial application of 3/4 pounds of DDT in one gallon of diesel oil per acre, applied at egg hatch time in 1965, should be effective in controlling the infestations.

PERSONNEL PARTICIPATING IN THE SURVEY

Name	Organization	Activity	Approximate Man Days
Pierce	USFS	Planning, Mapping, Survey, Report	30
Smola	USFS	Planning, Mapping, Survey, Report	28
Moore	USFS	Mapping, Survey, Report	18
Hall	Shafco	Planning, Survey	4
Dahlsten	U.C.	Parasite Study	In Progress
Herman	U.C.	Parasite Study	In Progress
Thorley	U.C.	Mapping	3
Pinzer	USFS	Survey	26
Duckworth	CDF	Survey	5
Rapalli	CDF	Survey	1
Ireland	CDF	Survey	4
Manning	Shafco	Survey	7
Marshall	Shafco	Survey	4
Davis	White Pine	Survey	4
Alway	Shafco	Survey	4
Dotta	CDF	Mapping, Survey	8
Shumaker	USFS	Survey	2
Winters	USFS	Survey	1
Osburn	CDF	Mapping, Survey	5
Chambers	USFS	Survey	2
Rennie	USFS	Survey	2
Fox	USFS	Survey	1
Wagener	CDF	Mapping, Survey	4
Dieter	USFS	Survey	2
Turner	USFS	Survey	2
Ramer	USFS	Survey	1
McBride	USFS	Survey	3
Siex	USFS	Survey	1
Glunt	Shafco	Mapping, Survey	4
Kennedy	USFS	Survey	1
Intorf	USFS	Mapping, Survey	2
Allen	CDF	Survey	1
Bayless	Shafco	Survey	1
Martin	USFS	Survey	1
Mitchell	USFS	Survey	1
Burwell	BLM	Survey	1
LeBarron	BLM	Mapping, Survey	3
Wragg	BLM	Survey	2
Wickman	PSW	Mapping	1
Hill	USFS	Mapping, Survey	2
Viers	USFS	Survey	3
Downing	PSW	Survey	1
Reynolds	USFS	Survey	1
Blomstrom	USFS	Survey, Report	3
			200 TOTAL

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(4) J. R. Pierce. 1964. Evaluation (Insects). Unpublished report dated July 8, 1964, 5230, of the survey conducted on June 18, 1964.

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(6) Scott Tunnock. 1963. Douglas-fir tussock moth infestations in northern Idaho and northwestern Montana - 1963. U. S. Forest Service, Division of State and Private Forestry, Region 1, Missoula, Montana 1380 (3000), November 1963.

(7) Harold R. Dodge and Galen C. Trostle. 1964. Douglas-fir tussock moth. Forest Pest Leaflet #86, U. S. Forest Service.

(8) S. F. Condrashoff and J. Grant. 1962. Sampling Douglas-fir tussock moth populations. Bi-Monthly Progress Report. Canada. Department of Forestry, Volume 18, Report Number 4, Page 4.

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U. S. FOREST SERVICE
Division of Timber Management
630 Sansome Street
San Francisco, California 94111

SUMMARY OF PLOT DATA COLLECTED

DURING THE SURVEY IN FALL 1964

KNOX MOUNTAIN

Defoliation Level	Cocoons Bearing Egg Masses: Number of Trees	Total Number Collected	1964	Older	Cocoons Without Egg Masses: Number of Trees	Total Number Collected	Emerged	Unemerged
Heavy (17 Plots)	85	4,595	4,434 96.5%	161 3.5%	10	2,106	986 46.8%	1,120 53.2%
Medium (24 Plots)	120	2,072	2,014 97.2%	58 2.8%	14	615	259 42.1%	356 57.9%
Light (41 Plots)	205	514	489 95.1%	25 4.9%	29	250	118 47.2%	132 52.8%
Very Light (119 Plots)	580	262	241 92%	21 8%	62	242	79 32.7%	163 67.3%
TOTAL (All Areas)	990*	7,443	7,178	265	115	3,213	1,442	1,771

*Eight plots not taken due to occurrence on nontype site.

KNOX MOUNTAIN - DDT

Defoliation Level	Cocoons Bearing Egg Masses: Number of Trees	Total Number Collected	1964	Older	Cocoons Without Egg Masses: Number of Trees	Total Number Collected	Emerged	Unemerged
Heavy	-	-	-	-	-	-	-	-
Medium	-	-	-	-	-	-	-	-
Light	-	-	-	-	-	-	-	-
Very Light (8 Plots)	40	35	0	35	5	2	2	0
TOTAL (All Areas)	25	35	0	35	1	2	2	0

KNOX MOUNTAIN - MALATHION

Defoliation Level	Cocoons Bearing Egg Masses: Number of Trees	Total Number Collected	1964	Older	Cocoons Without Egg Masses: Number of Trees	Total Number Collected	Emerged	Unemerged
Heavy	-	-	-	-	-	-	-	-
Medium (1 Plot)	5	25	18 72%	7 28%	-	-	-	-
Light (2 Plots)	10	31	25 80.6%	6 19.4%	1	33	22 66.6%	11 33.4%
Very Light	-	-	-	-	-	-	-	-
TOTAL (All Areas)	15	56	43	13	1	33	22	11

DIAMOND MOUNTAIN

Defoliation Level	Cocoons Bearing Egg Masses: Number of Trees	Total Number Collected	1964	Older	Cocoons Without Egg Masses: Number of Trees	Total Number Collected	Emerged	Unemerged
Heavy (3 Plots)	6	274	210 76.6%	64 23.4%	15	4,876	3,875 79.5%	1,001 20.5%
Medium (5 Plots)	25	170	128 75.3%	42 24.7%	25	1,758	1,450 82.5%	308 17.5%
Light (13 Plots)	65	176	132 74.9%	44 25.1%	70	2,140	1,495 69.9%	45 30.1%
Very Light (26 Plots)	130	73	32 43.8%	41 56.2%	90	870	734 84.4%	136 15.6%
TOTAL (All Areas)	226*	693	502	191	200	9,644	7,554	2,090

*Twelve plots not sampled due to occurrence in nontype site.

STOWE RESERVOIR

Defoliation Level	Cocoons Bearing Egg Masses: Number of Trees	Total Number Collected	1964	Older	Cocoons Without Egg Masses: Number of Trees	Total Number Collected	Emerged	Unemerged
Heavy	2	1,919	1,904 99.2%	15 0.8%	-	-	-	-
Medium	5	188	168 89.4%	20 10.6%	-	-	-	-
Light	5	161	149 92.5%	12 7.5%	1	93	88 94.6%	5 5.4%
Very Light	-	-	-	-	-	-	-	-
TOTAL (All Areas)	12	2,268	2,221	47	1	93	88	5

RONEY FLATS

Defoliation Level	Cocoons Bearing Egg Masses: Number of Trees	Total Number Collected	1964	Older	Cocoons Without Egg Masses: Number of Trees	Total Number Collected	Emerged	Unemerged
Heavy	5	59	41 69.5%	18 30.5%	-	-	-	-
Medium	10	75	54 72%	21 28%	-	-	-	-
Light	5	5	1 20%	4 80%	1	131	109 83.2%	22 26.8%
Very Light	-	-	-	-	-	-	-	-
TOTAL (All Areas)	20	139	96	43	1	131	109	22

FREDONYER PEAK (LASSEN CO. BLM)

BLM Land - 1,380 Acres
Private - 340 "
Total - 1,720 Acres

Defoliation Level	Cocoons Bearing Egg Masses: Number of Trees	Total Number Collected	1964	Older	Cocoons Without Egg Masses: Number of Trees	Total Number Collected	Emerged	Unemerged
Heavy	20	1,709	1,541 90.2%	168 9.8%	3	455	295 65%	160 35%
Medium	15	545	514 94.3%	31 5.7%	-	-	-	-
Light	15	496	484 97.5%	12 2.5%	2	35	18 54.3%	17 45.7%
Very Light	-	-	-	-	-	-	-	-
TOTAL (All Areas)	50	2,750	2,539	211	5	490	313	177

IRON MOUNTAIN AND BALTIC RIDGE

Defoliation Level	Cocoons Bearing Egg Masses: Number of Trees	Total Number Collected	1964	Older	Cocoons Without Egg Masses: Number of Trees	Total Number Collected	Emerged	Unemerged
Heavy (2 Plots)	10	28	3 10.7%	25 89.3%	-	-	-	-
Medium (5 Plots)	25	40	2 5.0%	38 95.0%	1	5	0	5
Light (4 Plots)	20	11	0	11	3	11	0	11
Very Light (5 Plots	25	8	0	8	3	14	14	0
TOTAL (All Areas)	80	87	5	82	7	30	14	16

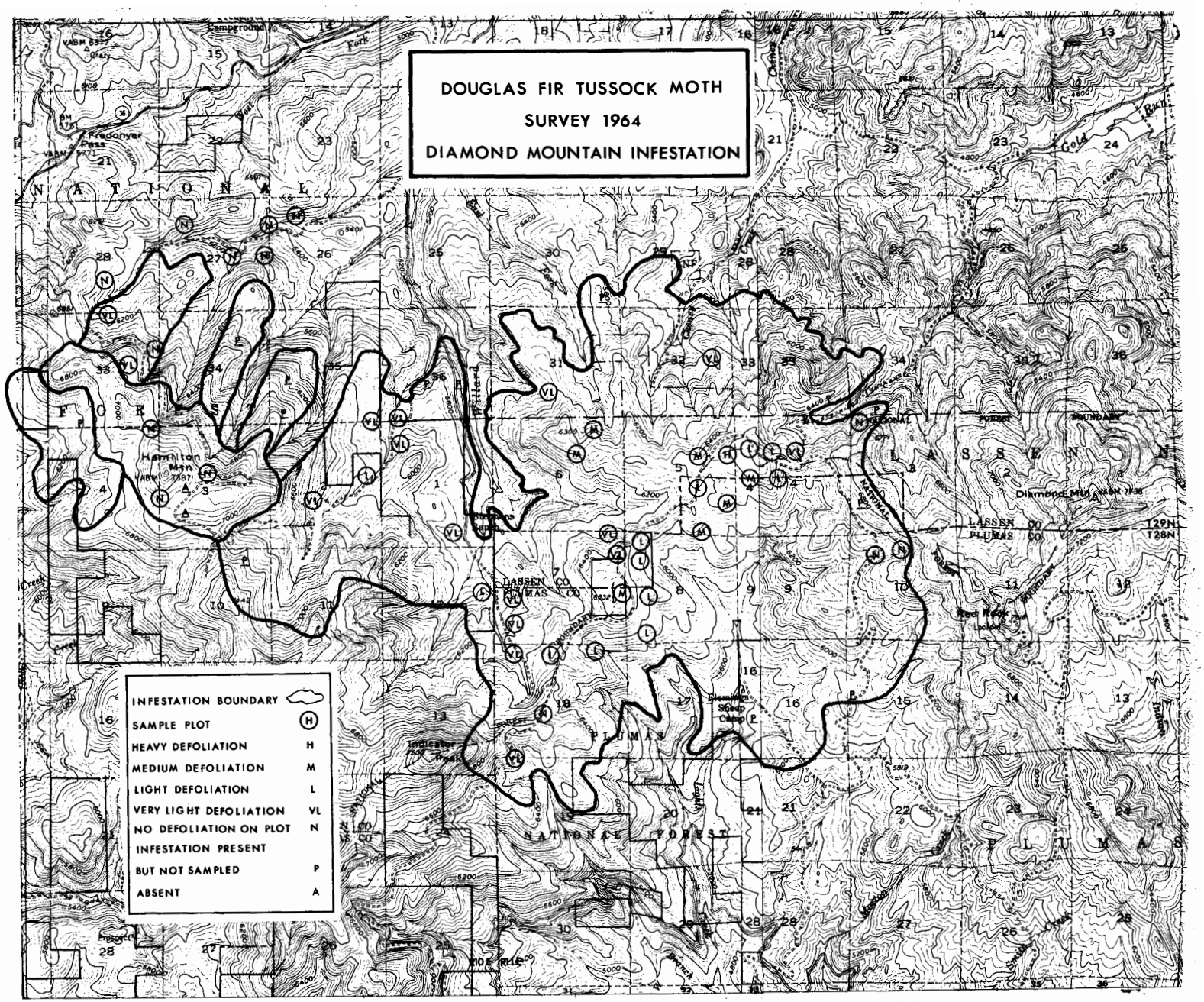
MAPS OF INFESTED AREAS

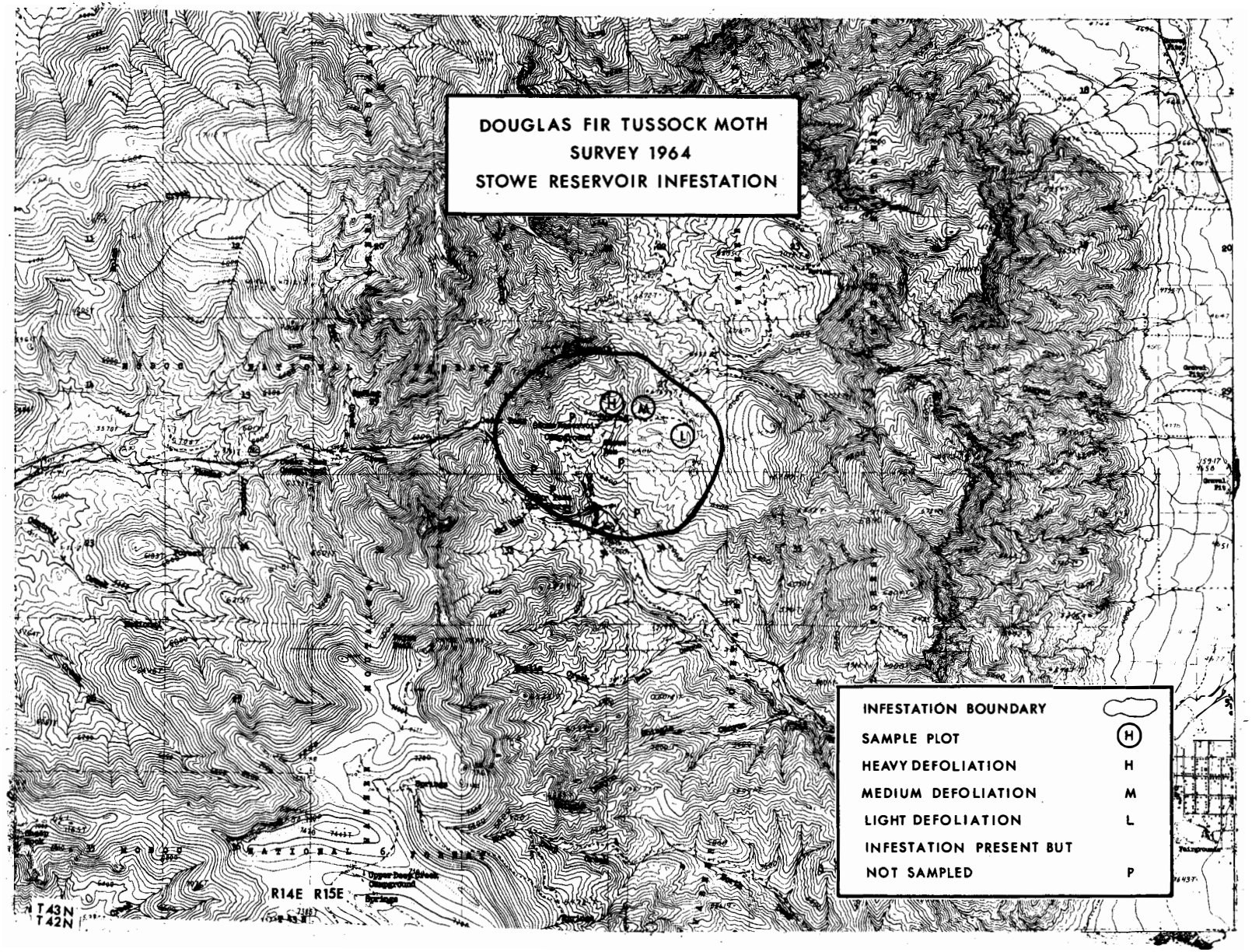
DOUGLAS FIR TUSSOCK MOTH
SURVEY 1964
KNOX MOUNTAIN INFESTATION

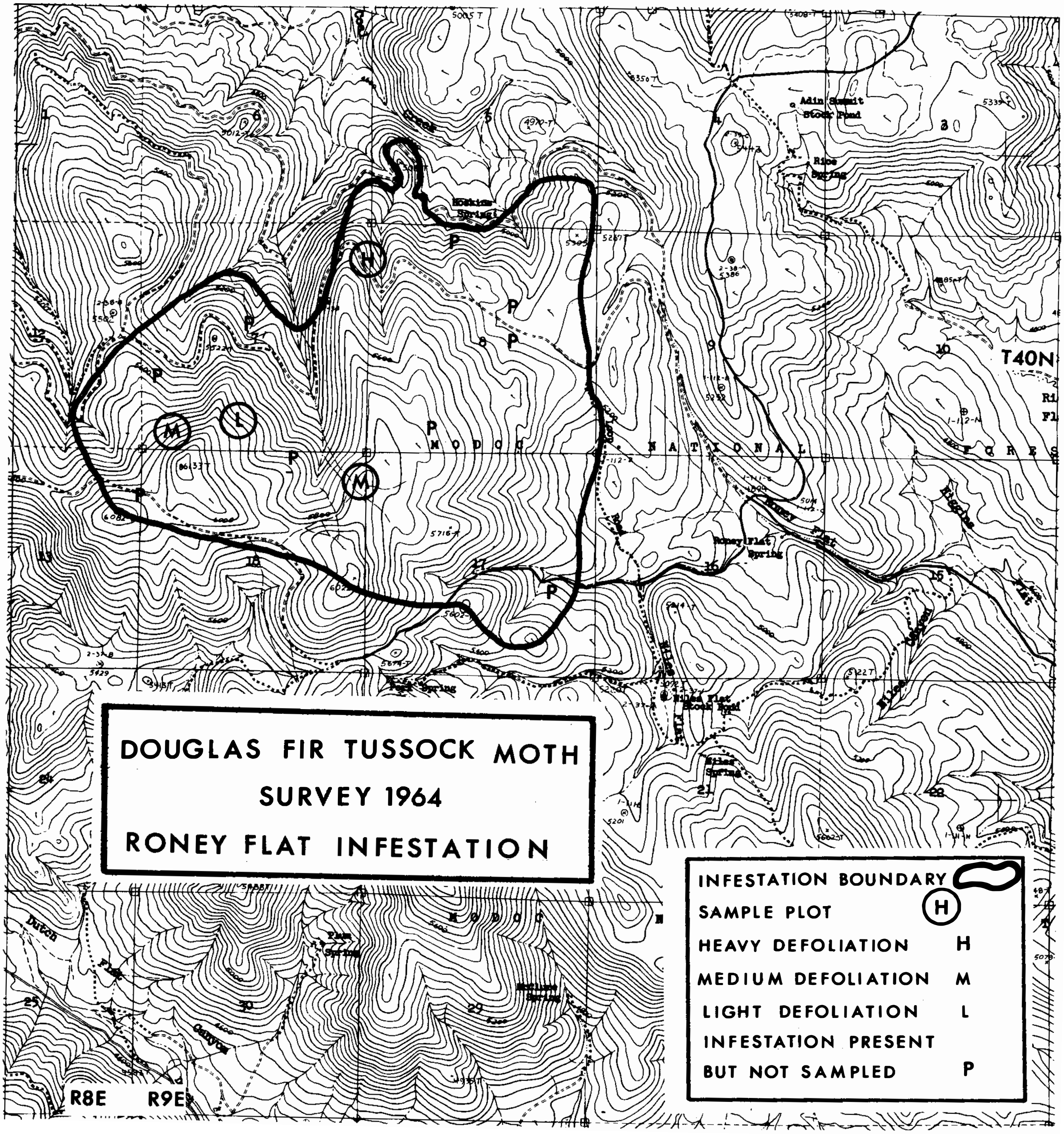
T40N
T39N

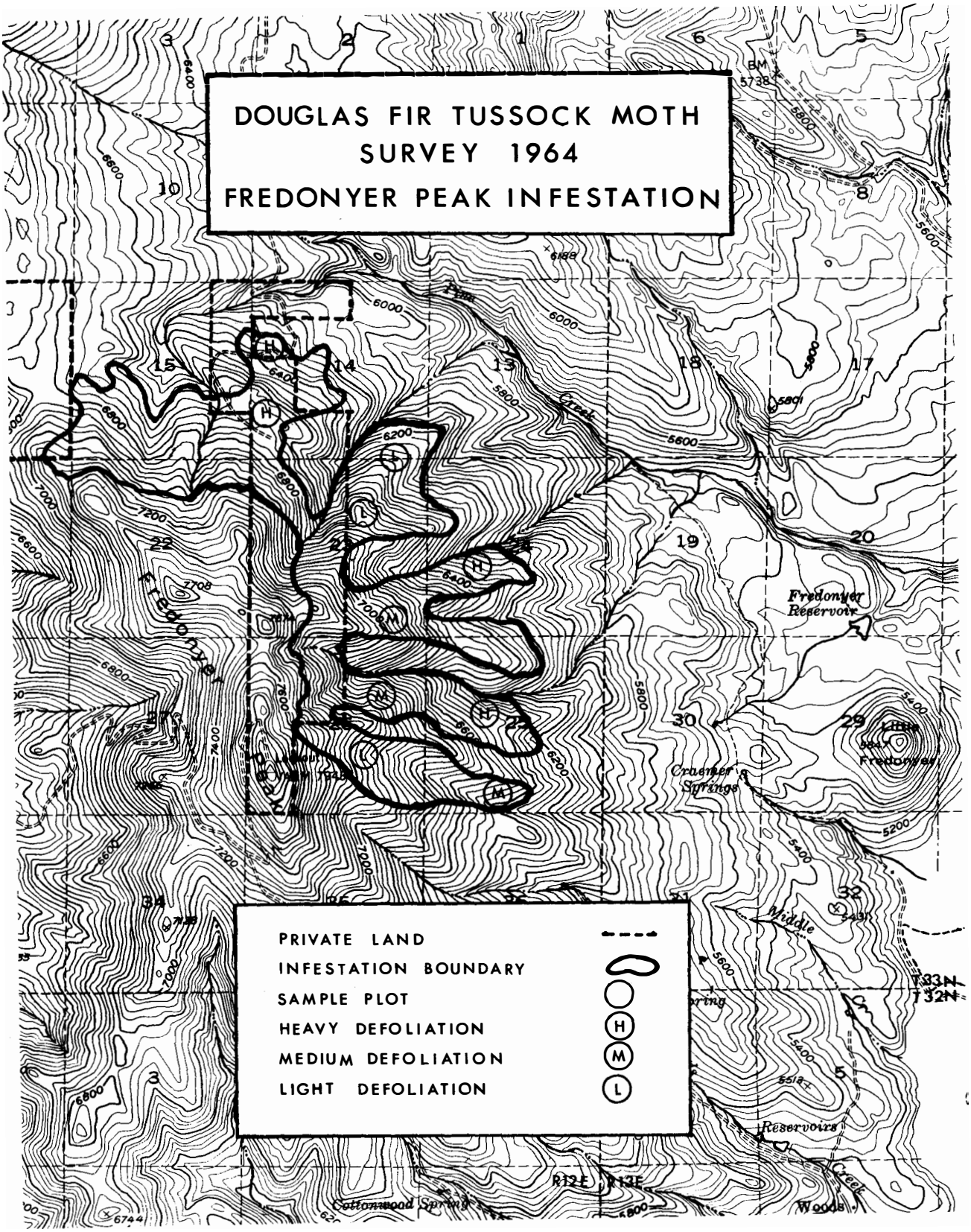
R10E R11E

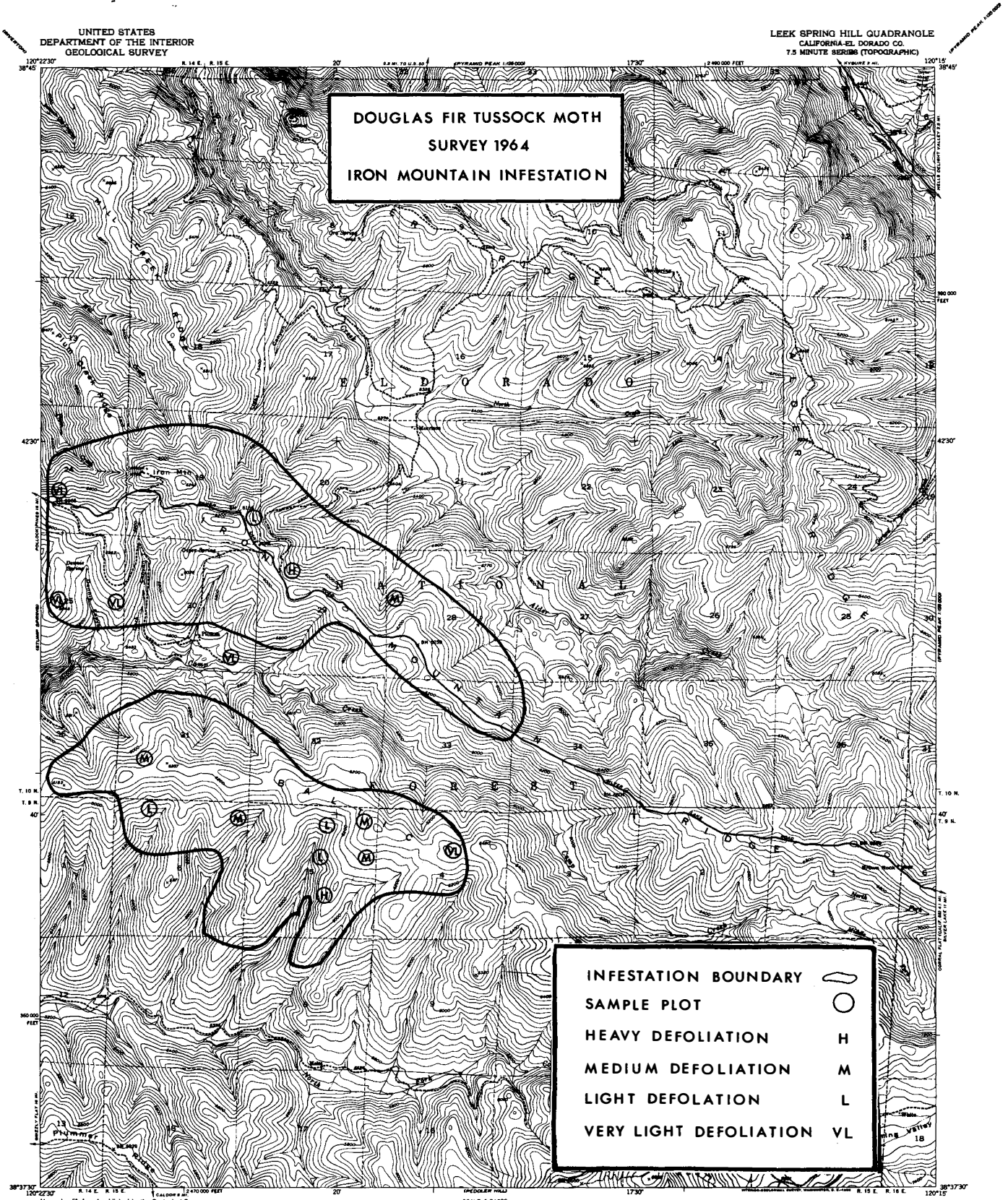
INFESTATION BOUNDARY	
SAMPLE PLOT	(H)
HEAVY DEFOLIATION	H
MEDIUM DEFOLIATION	M
LIGHT DEFOLIATION	L
VERY LIGHT DEFOLIATION	VL
NO DEFOLIATION ON PLOT	N


DOUGLAS FIR TUSSOCK MOTH
SURVEY 1964
DIAMOND MOUNTAIN INFESTATION
INFESTATION BOUNDARY
SAMPLE PLOT (H)
HEAVY DEFOLIATION H
MEDIUM DEFOLIATION M
LIGHT DEFOLIATION L
VERY LIGHT DEFOLIATION VL
NO DEFOLIATION ON PLOT N
INFESTATION PRESENT
BUT NOT SAMPLED P
ABSENT A
Hamilton Mtn
Diamond Mtn
Freedonyer Pass
Campground
PLUMAS NATIONAL FOREST
LASSEN NATIONAL FOREST
LASSEN CO
PLUMAS CO
T29N
T28N


DOUGLAS FIR TUSSOCK MOTH
SURVEY 1964
STOWE RESERVOIR INFESTATION
INFESTATION BOUNDARY
SAMPLE PLOT
HEAVY DEFOLIATION H
MEDIUM DEFOLIATION M
LIGHT DEFOLIATION L
INFESTATION PRESENT BUT NOT SAMPLED P
R14E R15E
T43N
T42N


DOUGLAS FIR TUSSOCK MOTH
SURVEY 1964
RONEY FLAT INFESTATION
INFESTATION BOUNDARY
SAMPLE PLOT
HEAVY DEFOLIATION H
MEDIUM DEFOLIATION M
LIGHT DEFOLIATION L
INFESTATION PRESENT
BUT NOT SAMPLED P
Adin Summit
Stock Pond
Rice
Spring
Roney Flat
Spring
T40N
R8E
R9E


DOUGLAS FIR TUSSOCK MOTH
SURVEY 1964
FREDONYER PEAK INFESTATION
PRIVATE LAND
INFESTATION BOUNDARY
SAMPLE PLOT
HEAVY DEFOLIATION
MEDIUM DEFOLIATION
LIGHT DEFOLIATION
Fredonyer Reservoir
Fredonyer Peak
Cranmer Springs
Middle Creek
Reservoirs
Cottonwood Spring
T33N
T32N
R12E
R13E


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
LEEK SPRING HILL QUADRANGLE
CALIFORNIA-EL DORADO CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
DOUGLAS FIR TUSSOCK MOTH
SURVEY 1964
IRON MOUNTAIN INFESTATION
INFESTATION BOUNDARY
SAMPLE PLOT
HEAVY DEFOLIATION H
MEDIUM DEFOLIATION M
LIGHT DEFOLATION L
VERY LIGHT DEFOLIATION VL
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Control by USGS and USC&GS
Topography from aerial photographs by multiplex methods
Aerial photographs taken 1948. Field check 1951
Polyconic projection. 1927 North American datum
10,000-foot grid based on California coordinate system, zone 2
Dashed land lines indicate approximate locations
Unchecked elevations are shown in brown
SCALE 1:24000
CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy-duty
Medium-duty
Light-duty
Unimproved dirt
U.S. Route
State Route
APPROXIMATE MEAN DECLINATION, 1951
THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
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1951